THE UPPER CONTACT PHASE OF THE SUDBURY MICROPEGMATITE

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ABSTRACT

Quartz pseudomorphic after tridymite has recently been recognized in the micropegmatite member of the Nickel Irruptive of the Sudbury Basin, Ontario. The "tridymite" occurs as blades radiating from quartz xenocrysts or adjacent to quartzite xenoliths, where the micropegmatite has brecciated and assimilated the overlying quartzite. A plume-like, almost spherulitic intergrowth of quartz and orthoclase is commonly associated with the "tridymite." These features indicate a high intrusion temperature, in the 800 to 900 degree range, and rapid cooling of the upper phase of the micropegmatite.

Quartz pseudomorphic after tridymite and spherulitic intergrowths have recently been recognized in the micropegmatite of the Sudbury Basin, Ontario.* These features, found in the upper part of the micropegmatite member of the Nickel Irruptive in the East Range (Fig. 1), point to its intrusion at a rather high temperature and to its rapid cooling. The evidence for this is seen in a zone 200 to 500 feet wide immediately above the normal micropegmatite. This zone consists of quartzite breccia and a fine to medium grained igneous rock that is neither the overlying tuff, fresh or altered, nor the underlying good normal micropegmatite.

The normal micropegmatite (Collins, 1934) is a medium grained pink weathering granitic rock that consists principally of euhedral albite-oligoclase surrounded by a beautifully developed micrographic intergrowth of quartz and orthoclase; the amount of micrographic intergrowth usually exceeds that of the plagioclase.

The principal rock type immediately overlying the normal micropegmatite is a close packed quartzite breccia (Stevenson, 1960 and 1961), usually about 200 feet wide, consisting of fragments that range from tens of feet to small ones measured in inches, often very closely packed together. This quartzite breccia is relatively continuous, particularly along the South Range, but along the East Range and in places along the South, it has been found to be interspersed and intermingled with a medium to fine grained dark grey rock that is neither the overlying good

*An excellent critical review of Sudbury geology has recently been given in this journal by Hawley (1962, 3–29).

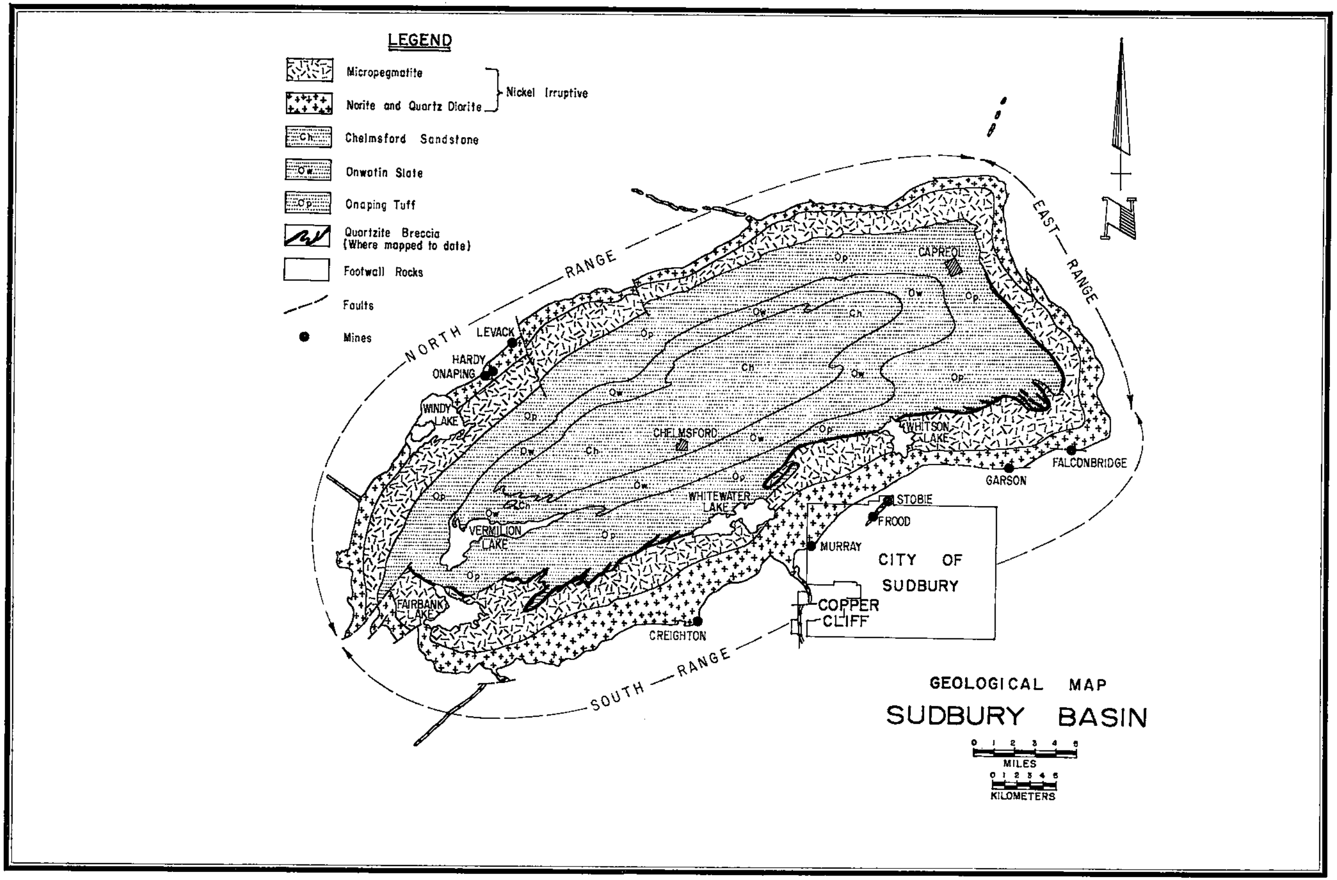

FIG. 1. Index map of the Sudbury Basin.

pyroclastic tuff of the Onaping formation (Burrows & Rickaby, 1930) nor the underlying good normal micropegmatite, but because of its colour in outcrop and because of features that relate it to the normal micropegmatite, it is here termed pepper-and-salt micropegmatite.

The areas of pepper-and-salt micropegmatite not only surround patches of close packed quartzite breccia, but extend beyond with only a small population of inclusions to a contact with definitely recognizable tuff. In general, this contact parallels the trend of the Basin contacts, but the pepper-and-salt with included quartzite often extends as indentations and tongues as long as several hundred feet into the overlying tuff. It is interesting to note that, just as in the Footwall rocks of the Sudbury Basin norite, thermal metamorphism of the tuff by the pepper-and-salt has developed diopside in the tuff.

In its most usual development the pepper-and-salt micropegmatite is a dark grey smoothly-weathering rock that contains a scattering of inclusions that include both quartzite and in places coarse grained "old granite," and it also contains megascopically visible xenocrysts of quartz and pink feldspar. Mineralogically the pepper-and-salt micropegmatite consists principally of anhedral quartz and orthoclase holding laths of plagioclase, sometimes arranged as in a glomeroporphyry. Minor amounts of actinolite and biotite are also found. The very abundant micrographic intergrowth that is characteristic of the normal micropegmatite is present in the pepper-and-salt. It varies rather strikingly in grain size from a medium grained rock slightly finer grained than the adjacent normal micropegmatite to a fine grained rock 500 feet away from the normal micropegmatite. This change in grain size is reflected most strikingly in a decrease in the size of the plagioclase laths.

The pepper-and-salt grades downward without marked textural or mineralogical break into normal micropegmatite. In mapping, an arbitrary contact between the two rocks is established where the micrographic intergrowth, characteristic of the normal micropegmatite, becomes an important constituent (10 per cent or more) of the rock. Even at some distance on either side of the arbitrary contact between the two rocks, textural and mineralogical features relate them genetically. These features include, apart from comparable quartz-orthoclase-plagioclase mineralogy, a marked dimensional similarity in the albite laths, and a usually recognizable, though variable, content of micrographic intergrowths.

The strikingly developed quartz pseudomorphic after tridymite is a feature of considerable genetic significance related to both the pepper-and-salt and the normal micropegmatite. It is found around and inside widely scattered inclusions of quartzite (Fig. 2) or of the occasional

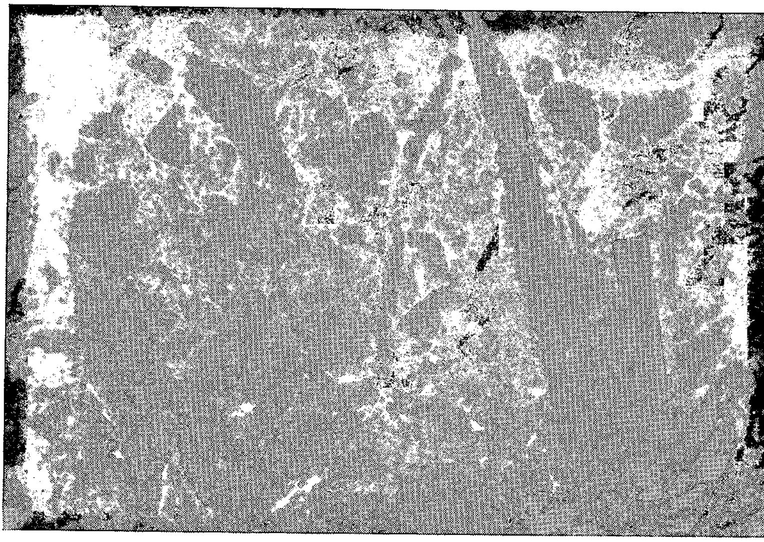

FIG. 2. Quartzite breccia East Range.

"old granite," wherever they are found in the lower part of the pepper-and-salt micropegmatite, or in the uppermost part of the normal micropegmatite. This "tridymite" (quartz pseudomorphic after tridymite) commonly occurs as long, well defined blades variously oriented in a granophyric matrix between quartz xenocrysts (Figs. 3 and 4) derived from nearby quartzite inclusions or from "older granite" inclusions. The "tridymite" is also found, with orthoclase or with a granophyric intergrowth of quartz and orthoclase, within brecciated quartzite fragments. Less well defined "tridymite" may be identified both in the pepper-and-salt and the normal micropegmatite at some distance, tens of feet, away from the larger quartzite breccia fragments. Such "tridymite" is usually associated with almost completely assimilated xenocrysts of quartz. L. R. Wager and W. A. Deer, in their comprehensive study of the Skaergaard intrusion in Greenland have recognized a type of quartz pseudomorphic after tridymite somewhat similar to that described above.

It would appear that the micropegmatite attacked the quartz grains of the quartzite breccia and gave rise to the tridymite fringes around the unassimilated portions of the grains (Figs. 3 and 4). On cooling, the tridymite would revert to quartz, but the lath-like shape of the orthorhombic tridymite would be retained, indicating that the quartz $\rightleftharpoons$ tridymite inversion temperature had been passed in the heating of the quartz grains by the micropegmatite (Shand, 1947, 56; Tyrrell, 1926, 301). It

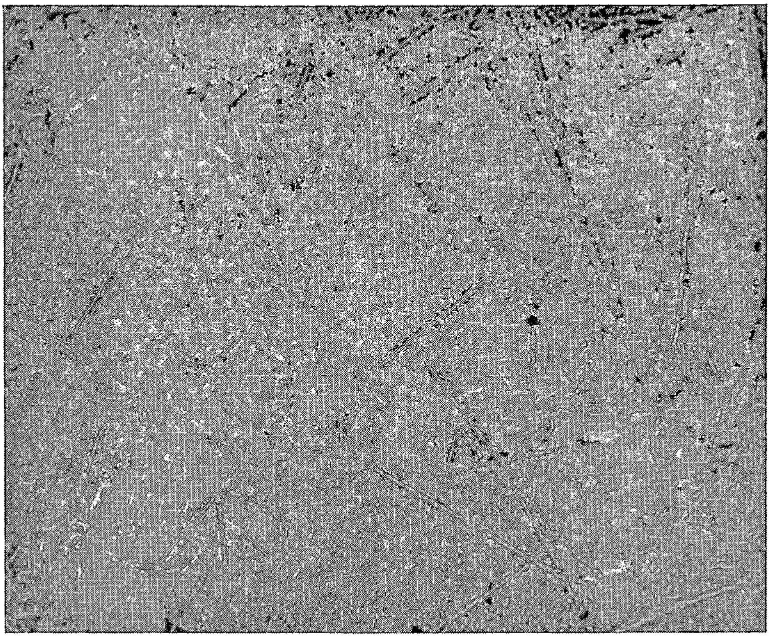

FIG. 3. Large blades of quartz pseudomorphic after tridymite, in a granophyric matrix, between quartz xenocrysts, East Range.
Plain light ×100.

is of interest to note that, in addition to the "tridymite" laths, quartz with hexagonal outlines is frequently seen around quartz xenocrysts and quartzite xenoliths and also, within the latter (Fig. 5). Quartz with such outlines may well represent hexagonal high temperature (beta) quartz, now inverted to low temperature (alpha) quartz. If so, it is probable that in such places the temperature of the micropegmatite was very close to the high quartz ⇆ tridymite inversion temperature.

The high quartz ⇌ tridymite inversion temperature at atmospheric pressure is 877° C. However, the considerable experimental work that has been done on the stability relations of the different forms of silica in dry systems and wet systems shows that this inversion temperature rises with increased external pressure and also with increased water vapour pressure (Berry & Mason, 1959), within the limits of the field of stability of tridymite. It has also been suggested that the presence of mineralizers or a content of foreign ions in tridymite might have a reverse effect on the field of stability of the tridymite. However, there are no minerals present in the micropegmatite that would suggest that these had been present in any quantity. Taking all these factors into con-

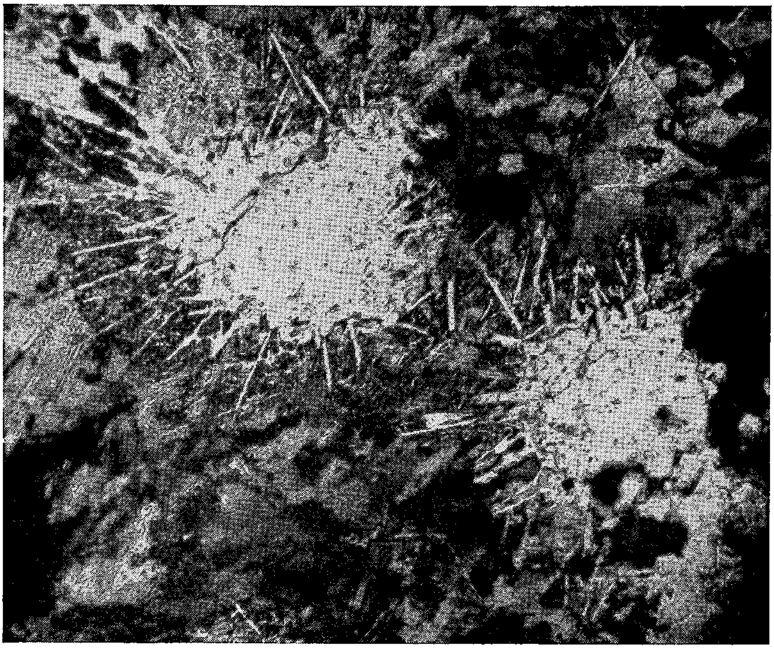

FIG. 4. Blades of "tridymite" radiating from xenocrystic areas of quartz, matrix, fine grained granophyre, East Range.
Crossed polars ×100.

sideration, it would appear that the intrusion temperature of the micropegmatite in and around the quartzite breccia was high, in the 800 to 900° C. range.

Commonly associated with the "tridymite," particularly in the quartzite breccia, there is a plume-like, almost spherulitic, intergrowth of quartz and orthoclase that frequently grades into a coarser-grained more normal micrographic intergrowth. Just as in the normal micropegmatite, euhedral laths of plagioclase are porphyritically kernelled in this intergrowth. The spherulitic nature of this intergrowth suggests rapid cooling of the micropegmatite magma. It would indeed be expected that the many cooling surfaces presented by the highly brecciated quartzite would induce rapid cooling of the invading magma.

Thus it would appear that we should extend the micropegmatite member of the Sudbury Basin Nickel Irruptive to include a fine grained upper phase into which it grades, and which decreases in grain size toward thermally metamorphosed tuff. Furthermore, the rather extensive development of quartz pseudomorphic after tridymite, and of spherulitic micrographic intergrowths, indicates a high intrusion temperature and rapid cooling of the micropegmatite.

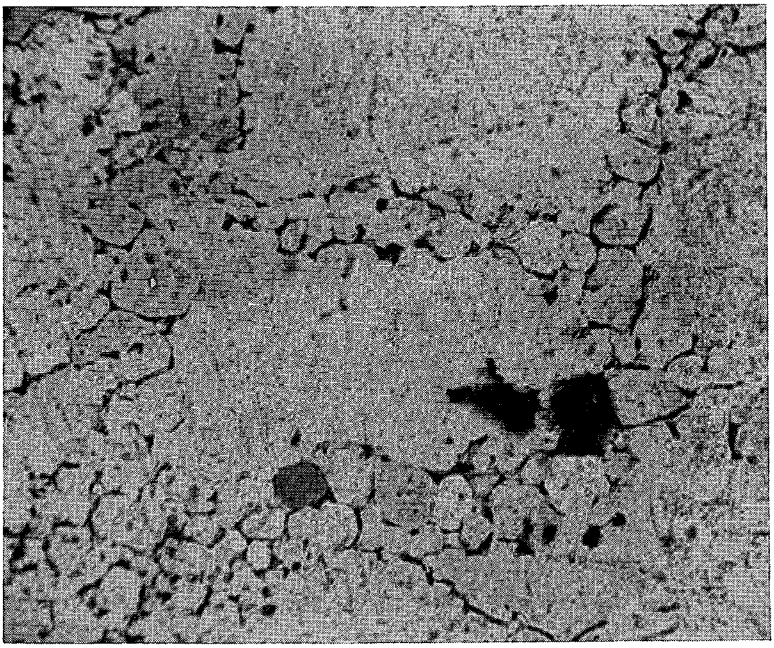

FIG. 5. Pattern of hexagonal shaped quartz grains (possibly inverted from high or beta quartz) within xenolith of quartzite, East Range.
Crossed polars ×100.

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REFERENCES

BERRY, L. G. & MASON, B. (1959): *Mineralogy*, W. H. Freeman & Co., 472–474.

BURROWS, A. G. & RICKABY, H. C. (1930): Sudbury basin area, *Ont. Dept. of Mines*, **38**, Pt. 3, 8–12.

COLLINS, W. H. (1934): Life-history of the Sudbury nickel irruptive, *Royal Soc. Can. Trans.*, Ser. 3, **28**, Sect. 4, 129.

HAWLEY, J. E. (1962): The Sudbury ores: their mineralogy and origin, *Can. Mineral.*, **7**, 1–206.

SHAND, S. J. (1947): *Eruptive Rocks*, Thos. Murby, London, 56.

STEVENSON, J. S. (1960): Origin of quartzite at the base of the Whitewater Series, Sudbury Basin, Ontario, *Int. Geol. Congress*, **21** *Sess., Norden, Rep.*, **26**, (*Supp. vol.*), *Sect.* 13, 32–41.

——— (1961): Recognition of the quartzite breccia in the Whitewater Series, Sudbury Basin, Ont., *Royal Soc. Can. Trans.*, Ser. 3, **55**, Sect. 4, 57–66.

TYRRELL, G. W. (1926): *Principles of Petrology*, Dutton & Co., N.Y., 301.